optic plate (or in general), a full compensation is secured by rotating the mirror nearest the telescope, provided it is the thinner of the pair. In such a case the system of mirrors will not be parallel, however, when the fringes are infinite in size (circles) and the zero position of the micrometer must be independently found, as one of the constants of the apparatus.

[1] See these PROCEEDINGS, 3, June, 1917, 412, 432, 436.
[2] From a Report to the Carnegie Institution, of Washington, D. C.

INTER-PERIODIC CORRELATION IN THE EGG PRODUCTION OF THE DOMESTIC FOWL

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In no animal organism except man has the investigation of the interrelationship of the various morphological and physiological characteristics of the individual by means of the modern methods of statistical analysis applied to large masses of quantitatively recorded observations been carried out on a more extensive scale than in the domestic fowl, to which Pearl and Surface, and others associated with them, have devoted their attention for a number of years.

Notwithstanding the many problems dealt with in this series of investigations, our knowledge of the interrelationships of characters of economic importance in this organism is still far from complete. Data from breeds different from those used by Pearl and Surface are particularly needed for purposes of comparison.

In an earlier paper[1] we discussed the correlation between the concentration of yellow pigment in the somatic tissues and egg production in the White Leghorn fowl. In the present investigation we have considered the correlations between the egg production of various periods.

The intensity of the correlation between the number of eggs laid in the several individual months and the total egg production of the year as a whole is shown by the solid dots in figure 1. A curve in excellent agreement was found for the previous year.

Economically these coefficients are of the greatest importance since they make possible the selection of groups of birds of high annual egg production from the trap nest records of individual months. Biologically they are in some degree spurious because of the fact that the cor-

relation is determined in each instance between the yield of an individual month and the yield of the entire year, which is made up of the yields of all the individual months. If the source of the partial spuriousness of these constants be removed by correlating between the records of the individual months and the total production of the remaining eleven months of the year, a better biological measure of the interdependence of egg laying activity in two periods is obtained. These are the results represented by the position of the circles on the ordinates for the individual months in figure 1. There is, as shown by the shaded area, a material reduction from twelve to eleven months by excluding the month used as the first variable in determining the correlation.

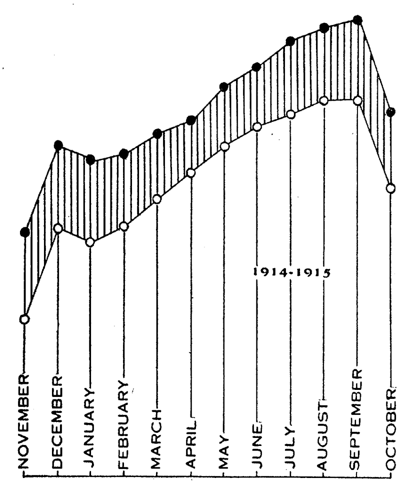

FIG. 1

The correlation between the production of single months and the production of the remaining eleven months of the year has, however, in every instance a substantial value. The coefficients range from 0.295 to 0.567 in the several months of 1913–1914 and from 0.240 to 0.567 in 1914–1915. The average reduction from the corresponding coefficients for 12 month periods is 20.45% in each year. Thus one must conclude that the birds are permanently, at least during the period of the first egg laying year, differentiated in respect of capacity for egg production.

The magnitude of the correlation coefficients measures on the universally applicable scale of -1 to $+1$ the closeness of interdependence of the egg production of the two periods. For purposes of prediction the correlation coefficients may be thrown into the form of linear

regression equations, which have been found to give reasonably good fits to the empirical means for the annual egg records of birds laying various numbers of eggs in the individual months. The slope of the lines when plotted shows there is an increase of from 2.6 to 5 eggs in mean annual production associated with a variation of one egg in monthly record. Since in practical selection groups of birds differing by far more than a single egg may be recognized, the difference in annual production secured by selecting in any month may be of very practical importance, amounting to from 30 to 60 eggs per year.

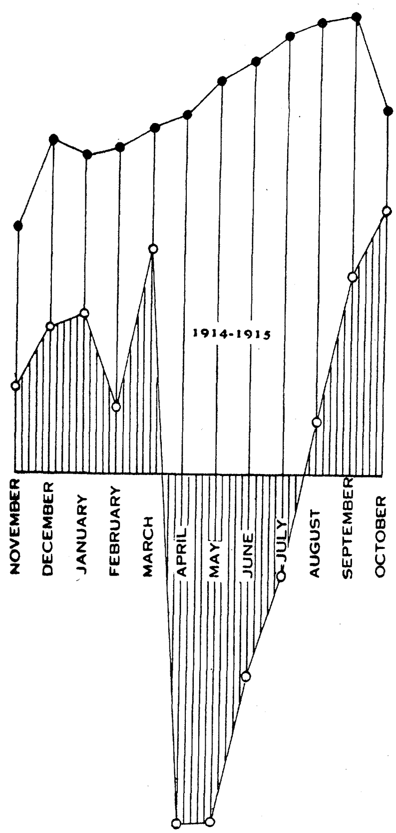

FIG. 2

While the correlation between the monthly egg record and the total annual production of the bird is the measure of the greatest practical value, forming as it does the basis for the prediction of average annual production from the observed performance of a limited period, neither it, nor the biologically more satisfactory correlation between monthly record and the production of the remaining eleven months, gives all

the information which the physiologist desires. A special coefficient due to Pearson and Harris[2] shows the correlation between the annual total and the deviation of the monthly record from the value which it should have if variation in monthly production were directly proportional to variation in the annual production. Figure 2 gives the results for 1914–1915—those for the preceding year being similar.

The coefficients show that in both years the winter months November, December, January and February and the following autumn months, September and October, show an increase over their theoretical quota of eggs when the annual egg production rises above the normal. The spring and summer months, March, April, May, June and July, show a lower relative contribution to the annual total than is theoretically to be expected when this total varies in the direction of an increase above the mean annual egg production of the flock as a whole. Thus in the diagram the coefficients in both years increase from November to December or January, then drop to the first negative value of the year in March and reach their numerically negative largest value in April, after which they rise and become positive in sign but numerically very low in August and attain their maximum positive value in October.

A knowledge of the correlation between the egg records of the individual months is essential to a full understanding of the physiology of egg production in the fowl. We have worked out sets of correlations, 110 coefficients in all, for the production of five of the individual months and the production of each of the other months of the contest year. The months selected are November of the pullet year and the following October and three intervening months, January, April and August.

The fact that these 110 coefficients are without exception positive in sign seems to us a result of very material biological significance. It indicates that if abnormally high laying at one period tends, as the result of nutritional or other physiological factors, to result in abnormally low production during a subsequent period, the reduction is not sufficient to outweigh the influence of the initial differentiation of the birds in their capacity for egg production suggested above.

Two laws are evident in these inter-mensual correlations. These are to some degree mutually obscurant and must be considered in their mutual relations, but for the sake of simplicity may be stated categorically.

1. The correlation between the egg production of the individual months tends to become smaller as the records upon which the correlations are based become more widely separated in time.

2. There is a more intimate correlation between the egg production

of the autumn and winter months at the beginning and end of the contest year than between the egg production of these months and the productions of the intervening spring and summer months.

The relationship between the intensity of correlation and the degree of separation of the periods of egg production compared is best illustrated by the results for April and the five preceding and the six following months. The magnitude of the constants decreases with fair regularity from March to the preceding November and from May to the following October.

The second law is best exemplified by the coefficients measuring the relationship between November or October production and the record of the other months. Note that in the biological year of this investigation these months do not fall in the same but in different calendar years.

The results are to appear in detail in *Genetics*.[3]

[1] Harris, Blakeslee, Warner, and Kirkpatrick, *Genetics, Cambridge*, **2**, 1917, (36–77). Also these PROCEEDINGS, **3**, 1917, (237–241).

[2] Harris, *Biometrika, Cambridge*, **6**, 1909, (438–443).

[3] A treatment of the relationships between part of the year's yield and the output for the entire year is in preparation by Mr. L. E. Card for a Bulletin of the Storrs Experiment Station.

TWO LAWS GOVERNING THE IONIZATION OF STRONG ELECTROLYTES IN DILUTE SOLUTIONS AND A NEW RULE FOR DETERMINING EQUIVALENT CONDUCTANCE AT INFINITE DILUTION DERIVED FROM CONDUCTIVITY MEASUREMENTS WITH EXTREMELY DILUTED SOLUTIONS OF POTASSIUM CHLORITE

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Any theoretical interpretation, in terms of the Ionic Theory, of the properties and behavior of any solution containing electrolytes involves as one of its essential factors a knowledge of the degrees of ionization of the electrolytes present in the solution. The most reliable method of determining the degree of ionization, α_C, of a uni-univalent electrolyte at the concentration C is by means of the relationship, $\alpha_C = \Lambda_0/\Lambda_C$, where Λ_C is its equivalent conductance (corrected if necessary for viscosity effects) at the concentration C, and Λ_0 is its equivalent conductance at zero concentration.

The value of Λ_0 is usually obtained by extrapolating to zero concentration, some empirical function which is found to represent more